Pain Experience in Social VR: The Competing Effect on Objective Pain Tolerance and Subjective Pain Perception

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Abstract

The distractive qualities of virtual reality are known to decrease pain. As technology develops, new opportunities to augment VR's distractive capacities are arising. For example, social interaction in virtual reality can increase distraction and possibly also provide social support. Below, we describe a pilot study designed to investigate whether interacting with an attachment figure versus interacting with a stranger in the virtual world would yield any difference on participants' pain ratings and pain threshold in an experimental pain task. We designed a within-group single-factor experiment with three conditions; being alone in VR, interacting with an attachment figure in VR, and interacting with a stranger in VR. We aimed to investigate the effect on participants of distinct attachment styles in close relationships. In preliminary findings, we observed trends for the highest tolerance for mild induced pain when participants interacted with their loved ones. Besides, participants reported the most severe perceived pain when interacting with strangers in VR. We discuss implications for future work.

Index Terms: Human computer interaction (HCI)—Interaction paradigms—Virtual reality

1 Introduction

The effect of virtual reality (VR) intervention on pain perception is a long-standing area of research [6]. How can interpersonal interactions in VR impact users' cognition and behavior, and how can these then mediate their reactions in the real world? Besides distracting patients from their painful experience, social interaction in VR can leverage multiple socio-psychological and behavioral effects to reduce patients' perception of pain. Below, we describe a pilot study investigating whether differences in social context (i.e., interacting with close others versus interacting with strangers) have different effects on individuals' pain perception, and whether *attachment style* (i.e., a person's inclinations in a close relationship) could interfere with this effect.

2 Related Work

Research across disciplines has suggested the potential of pain alleviation through social interaction and pointed to oxytocin as one factor [5]. Oxytocin is also known for its crucial role in leveraging social behaviors, including attachment, empathy, social warmth, and interpersonal contact. Moreover, the pain-relieving capability of oxytocin may be augmented when an interpersonal contact is formed with a person's attachment figures [1]. Therefore, social interaction with close others may alleviate pain through a heightened level of oxytocin secretion, diminishing pain stimulus processing and reducing negative affect.

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On the other hand, other research on texting has found that patients chatting with strangers required significantly less pain relief than those chatting with loved ones [4]. It is possible that interacting with strangers in a virtual world would further alleviate one's pain because it is more cognitively demanding and thus more distracting. For example, previous studies have found talking with strangers to reduce the need for pain relief compared to talking with loved ones. Thus, we aim to compare the effect of interacting with attachment figures versus interacting with strangers in VR on participants' pain tolerance for induced experimental pain, and their pain ratings.

3 Research Design

The present study conducted a within-group single-factor study with three conditions: (1) *Alone* condition: participants were alone in VR, (2) *Loved Ones* condition: participants interacted with their attachment figures in VR, and (3) *Strangers* condition: participants interacted with strangers in VR. The *Alone* condition was planned as a control condition to compare the distinct effect of the later two social circumstances. Participants performed two baseline conditions before the experimental conditions in an effort to reduce order effects. However, we note that in this pilot study the order of conditions was not randomized.

In the study, we induced mild thermal pain using the Medoc thermode [3], where participants placed their non-dominate hands on a thermal plate which slowly heated up from 32°C at a rate of 0.5°C/sec. Participants were instructed to remove their hands from the thermal plate as soon as they became uncomfortable. When the thermal plate reached the maximum heat of 50°C, it was calibrated to turn off automatically to prevent any potential harm on participants' skin. We then recorded the peak temperature as a measure for participants' pain tolerance. In addition, participants were asked to rate their pain immediately after each experimental condition. Throughout the study, we also collected participants' oxytocin and cortisol levels using saliva samples as a bio-physiological measure. These samples are currently being processed.

4 Participants and Procedure

This study was approved by the IRB. We recruited six pairs of study subjects from the participant pool of a large university in the United States. Participants were asked to sign up with a close friend, romantic partner, or family member. One week prior to the study, both participants were asked to complete a pre-study survey on their attachment styles in close relationships [2]. This survey also captured their demographic data and their former experience with severe pain, chronic pain, and their use of medication for pain relief. Both participants received either course credits or cash for compensation. We randomly assigned one individual of each pair to experience mild induced pain (i.e., the *Pain* participant), while the other person (i.e., the *Non-Pain* participant) would not go through pain simulation.

The experiment was conducted as follows: After participants consented, we collected a oxytocin sample and measured participants' pain tolerance to a mild heat stimulus for the first time to familiarize them with the study process and stimulus. We then performed a brief training to help participants get familiar with navigating in VR, during which they watched a 360° video in VR and completed a second experimental pain task. Next, the three experimental conditions were presented in the following order. In the *Alone* condition, participants watched a pre-recorded clip of two avatars discussing the same 360° video they had just viewed. Following, in the *Loved Ones* condition, participants were asked to discuss with their attachment figures about the 360° video. Finally, in the *Strangers* condition, they discussed the video content with a ”stranger” (an unknown research assistant confederate). Each of the three interventions lasted for 5 minutes. Throughout the study, saliva sampling were consistently performed every 15 minutes, each immediately prior to the start of a new experimental conditions.

5 Results

Though we are not able to draw any statistically significant conclusion due to the small sample size of the pilot study, we observe two common trends regarding participants' pain perception. Participants demonstrated increased pain tolerance while interacting with their close partners (*M*= 46.98, *S.D.*= 2.57), followed by interacting with strangers (*M*= 46.47, *S.D.*= 2.93) and alone in VR (*M*= 45.75, *S.D.*= 3.36. For subjective pain perception, participants reported the highest scores on the standard pain measurement scale while interacting with strangers (*M*= 5.00, *S.D.*= 2.55), followed by interacting with their attached figures (*M*= 4.80, *S.D.*= 1.79) and alone in VR (*M*= 4.40, *S.D.*= 1.82.

In addition, using a linear regression model, we identified that other than the experimental conditions, participants' level of anxiety ($Std.\beta = 2.49, S.E. = 1.79$), level of avoidance ($Std.\beta = .47, S.E. = .86$), former experience in VR ($Std.\beta = 2.28, S.E. = 1.75$), perceived novelty ($Std.\beta = -.85, S.E. = .34$), and sense of presence ($Std.\beta = .33, S.E. = .53$) all predict participants pain experience during VR interventions. Adopting these variables in univariate analyses, we calculated predicted scores for individuals' pain tolerance and pain perception. Results are plotted by one's attachment styles in Figure 1. In the current pilot study, we obtained subjects of dismissing (low anxiety, high avoidance), preoccupied (high anxiety, low avoidance), and secure (low anxiety, low avoidance) attachment styles. Participants' pain tolerance by attachment styles differed to a lesser extent than their pain perception. In particular, participants with preoccupied styles reported the highest degree of perceived pain, followed by those of dismissing styles, and the lowest among secure participants. The same pattern was observed across all three experimental conditions.

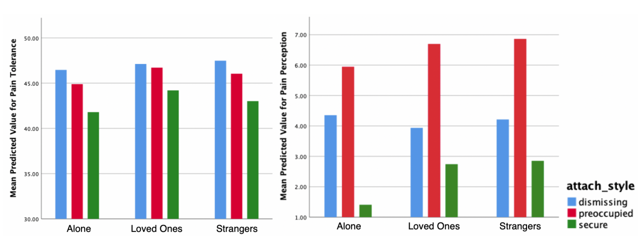

Figure 1: Predicted mean value of pain tolerance (left) and pain perception (right) by attachment styles and experimental conditions.

6 Discussion and Future Work

With the present pilot study, we compared the effect of different social contexts on pain experience in VR and observed different patterns among participants with different self-reported attachment styles. Overall, we found participants demonstrated the highest pain tolerance when interacting with loved ones. Consistent with these results, participants reported the greatest perceived pain in the *Strangers* condition. However, there were some differences in attachment styles, such that participants who reported secure or anxious attachment styles may benefit from interacting with a loved one, while participants with an avoidant attachment style did not see the same benefits.

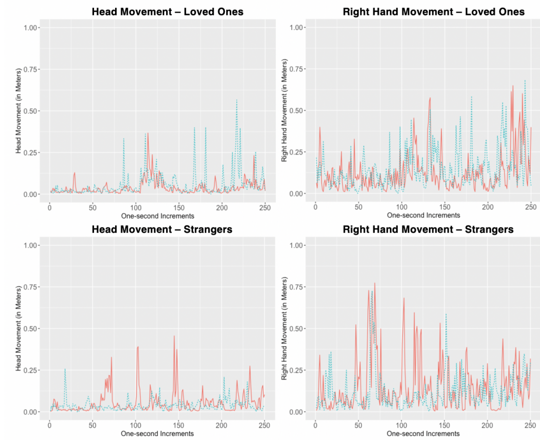

Figure 2: Head and right hand movement of *Loved Ones* and *Strangers* conditions.

Next steps will include refining our saliva collection measures after receiving the results of the initial assay, presenting the conditions in a random order, and adding the analysis of movement data to our study. For example, looking at the traces of nonverbal synchrony between two participants may give us clues to what kind of interactions with loved ones or strangers are most helpful. In figure 2, we show examples of these kinds of traces.

The present study indicates the need for future work to include additional qualitative measurements, allowing participants to elaborate both their pain and social interaction experience. We hope that this will contribute to better understanding of how to further augment the effectiveness of virtual reality for pain.

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